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April 14, 2014

Mr. Dave Henderson, P.E.
Roanoke County Engineer
Roanoke County Department of Community Development
5204 Bernard Drive
P.O. Box 29800
Roanoke, Virginia 24018 - 0798

Dear Mr. Henderson:

The Virginia Department of Environmental Quality (DEQ) appreciates your participation in the development of the Roanoke River Watershed Clean-up Plan. DEQ received your comments and questions via email attachment on February 27, 2013 (Roanoke County_2013 Year 5 Annual MS4 Report.pdf) and verbally during the February 28th Working Group meetings. The following attachment contains your comments and DEQ's responses.

DEQ appreciates Roanoke County's continued interest and participation in the TMDL Implementation Plan development process. Please feel free to contact me at 540.562.6715 or mary.dail@deq.virginia.gov if you have questions.

Sincerely,

Mary R. Dail
TMDL Project Coordinator

Ec: Ms. Liz McKercher, Ms. Jaime Bauer, Mr. Charlie Lunsford (DEQ)

Enc: DEQ Responses to Roanoke County Comments, Approaches for Estimating PCB Loadings from MS4s and Non-regulated Storm Water for TMDL Development of the Tidal James River Estuary (3/1/2012)

DEQ Response to Roanoke County Comments
Comments submitted on 27 February 2014
DEQ Response prepared by: DEQ Central Office TMDL and MS4 Staff and Blue Ridge Regional Office TMDL Staff

Roanoke County Statement: Through its MS4 Permit, effective July 1, 2013, Roanoke County is required to develop TMDL Action Plans for each of its impaired streams, by July 1, 2015. These Action Plans must include the steps that Roanoke County intends to take to meet its wasteload allocations. Therefore a clear understanding of the TMDL studies that developed the wasteload allocations and the County's current yearly pollutant discharges are critical to ensure that the County develops effective Action Plans that meet the regulatory requirements and are cost-effective for its citizens. Following are some issues that Roanoke County desires to clarify with the assistance of DEQ.

DEQ Comment: With respect to general and individual MS4 permits, implementation of and compliance with local TMDL wasteload allocation(s) will be achieved through permit reissuances and the required MS4 Program Plan updates. More specifically, permittees will be required to update their MS4 Program Plans to include TMDL Action Plans to address local TMDL wasteload allocations as permits are reissued. TMDL Action Plans will identify BMPs and other management strategies to be implemented by the MS4 owner to achieve compliance with the TMDL wasteload allocation. TMDL Action Plans can be implemented in multiple phases over multiple permit cycles using an adaptive iterative approach (i.e. the action plans can and most likely will be revised) provided that permittees demonstrate adequate progress in achieving the WLA(s). Implementation of the TMDL Action Plans is tracked via annual reports prepared by the MS4 owner.

TMDL Implementation plans (IPs) are designed to meet TMDL pollutant reduction goals within a watershed based on landuse. IPs may be utilized by localities for pollutant reduction strategies; however they are not considered a requirement for permit compliance. Further, IPs do not prescribe specific BMPs for localities to implement to meet their MS4 permit requirements.

Roanoke County Comment 1: Roanoke County understands that the MS4 area that is covered by the wasteload allocations are the urban lands as designated by the U.S. Census in its latest census. Due to the 2010 census, Roanoke County's urbanized area was enlarged. Roanoke County's wasteload allocations need to be adjusted by DEQ to account for this change.

DEQ Response: Localities are responsible for meeting wasteload allocations (WLAs) assigned in Environmental Protection Agency (EPA) and State Water Control Board (SWCB) approved TMDLs. DEQ recognizes the need to modify the existing sediment, bacteria and PCB TMDLs for the Roanoke River. The modification process is time consuming and will be prioritized accordingly. A date for modifying these TMDLs has not been established. Until an approved modification is in place, current WLAs apply.

Roanoke County Comment 2: The Tinker Creek TMDL Study and Roanoke River and Ore Branch TMDL Study indicate, respectively, that a 75% and 99% reduction in E-Coli would be required to meet the wasteload allocations. However, Roanoke County's calculations using the Simple Method, and information from its GIS system indicate that all of its streams that have wasteload allocations for E-Coli are in compliance, except for Ore Branch. Roanoke County's calculations indicate that Ore Branch requires a 50% reduction in E-Coli, rather than the 99% reduction that is identified in the TMDL study. Roanoke County desires to work with DEQ to better understand the differing results from the TMDL studies and Roanoke County's calculations.

DEQ Response: WLAs should be addressed in MS4 TMDL Action Plans and localities are encouraged to discuss MS4 permit requirements with DEQ MS4 Staff.

In reviewing Roanoke County's calculations, Central Office TMDL Program staff noted two misapplications of the fecal coliform (FC) to E. Coli (EC) bacteria translator. Specifically, the translator translates FC/100 ml to EC/100 ml; whereas, it appears that the County translated FC/ml to EC/ml. Also, the translator has a cap of no more than 100,000 FC counts/yr.

The Simple Method is a technique used for estimating storm pollutant export delivered from urban development sites. The Simple Method Calculation is intended for use on development sites less than one square mile in area, 640 acres (personal communication with Tom Schuler, originator of Simple Method). The main reason for the drainage area limitation is that the Simple Method does not compute pollutant loads during dry weather conditions. These loads can be significant as drainage area increases. Above that specified area, Schuler recommends the use of the Watershed Treatment Method (WTM) that is available from the Center for Watershed Protection's website. Lick Run appears to be the only watershed that is less than 640 acres. Schuler concludes that since most bacteria monitoring data is variable; he has less confidence in the Simple Method providing anything more than general source assessment and WTM is the fallback.

DEQ adheres to certain requirements for TMDL development and utilizes EPA accepted methodology and tools for developing said TMDLs. WLAs in State Water Control Board and EPA approved TMDLs are considered regulatory until an approved TMDL modification is finalized.

Roanoke County Comment 3: The Roanoke River Benthic TMDL Study indicates that an approximate 69.5% reduction in sediment from developed lands and from in-stream erosion is necessary to meet the wasteload allocations. However, Roanoke County's calculations using the Simple Method, and information from its GIS system indicate that the Roanoke River is in compliance with its wasteload allocation. Roanoke County desires to work with DEQ to better understand the differing results from the TMDL study and Roanoke County's calculations.

DEQ Response: See response to Roanoke County Comment 2.

Roanoke County Comment 4: The Roanoke River PCBs TMDL Study needs to be revised to give the Town of Vinton a share of the wasteload allocation.

DEQ Response: Noted. Please see DEQ Response to Comment 1 regarding TMDL modifications. Town of Vinton's WLA will be calculated when Roanoke River Watershed PCB TMDL is modified. Roanoke River Watershed Clean-up plan is not intended to address PCBs.

Roanoke County Comment 5: Roanoke County is unaware of any good empirical method to calculate PCBs yearly discharge from a watershed.

DEQ Response: Please see the enclosed document used in TMDL Development of the Tidal James River Estuary. There may be other resources available.

Roanoke County Comment 6: The calculated E-Coli and Sediment discharges are based solely on land use and precipitation values. Impacts from existing BMPs are not reflected in these calculations.

DEQ Response: Watershed models are just one tool used in TMDLs to simulate conditions within a watershed and allow for adjustments to be made (reflected in the TMDL scenarios) in order to predict water quality outcomes. The Hydrologic Simulation Program – Fortran (HSPF) was used to model watersheds and develop bacteria TMDLs in *The Bacteria TMDLs for Wilson Creek, Ore Branch and the Roanoke River Watersheds* and (Roanoke River Bacteria TMDLs) and *Fecal Coliform Total Maximum Daily Load Development for Glade Creek, Tinker Creek, Carvin Creek and Lick Run* (Tinker Creek TMDLs). These reports are available on DEQ's website. HSPF modeling process is discussed in Chapter 4 (beginning on page 4-1) of both Bacteria TMDLs report. A variety of bacteria sources are included in the model and the approach to accounting for each source is described beginning on page 4-11 and 4-2 of the Roanoke River Bacteria TMDLs and Tinker Creek TMDLs, respectively. HSPF was calibrated for various flow components by ensuring that simulated values match observed flow conditions from USGS gage data. Climate and rainfall information was gathered from the Roanoke Airport and Pulaski gage as discussed on page 4-24 of the Roanoke River Bacteria TMDLs. A detailed comparison of this process including the calibration results may be viewed starting on page 4-26 and 4-17 in the Roanoke River Bacteria TMDLs and Tinker Creek TMDLs, respectively. Bacteria die-off is factored into the modeling (p. 4-19 in Roanoke River Bacteria TMDLs and p. 4-5 in Tinker Creek TMDLs). Calibration parameters are described in Table 4-12 of the Roanoke River Bacteria TMDLs and in Section 4.6 (beginning on page 4-17) of the Tinker Creek TMDLs. Water quality calibration of the model was achieved using empirical data from DEQ's water quality monitoring database (p. 4-34, Roanoke River Bacteria TMDLs and p. 4-39, Tinker Creek TMDLs). This part of the process is iterative whereby modeling results are compared to empirical data and adjusted as needed until there is acceptable agreement between observed and simulated bacteria concentrations. BMPs that were in existence prior to TMDL development would be reflected in water quality data used in model calibration.

For the Benthic TMDL development *(Benthic TMDL Development for Roanoke River),* it is important to note that an extensive weight-of-evidence approach called stressor analysis was performed in order to identify sediment as the most probable stressor causing the benthic macroinvertebrate community to shift. Once the stressor was determined, the Generalized Watershed Loading Function (GWLF) model was chosen as the appropriate tool to simulate sediment loading within the Roanoke River watershed. Sediment loading was determined for each source as described in chapter of the Benthic TMDL report. Two GWLF models were developed: one for the reference (or "unimpaired") watershed and one for the impaired Roanoke River watershed. Hydrology calibration is performed in order to ensure that the model is representing flow conditions realistically.

Water quality monitoring data is available by request. It is also important to remember that a vast amount of public participation occurred throughout the TMDL development processes to ensure that bacteria and sediment sources were reasonably represented in the modeling. Where possible, appropriate technical personnel were enlisted to evaluate and provide input on specific source categories (i.e. agriculture, septic systems, straight pipes, etc.).

Roanoke County Comment 7: As the County's GIS system is improved to better locate and quantify their beneficial effects, they will be integrated into future water quality calculations. I would like a better understanding of the entire TMDL study process. From reading the report, it is difficult to understand (at least for me)what monitoring information they were based on , how that monitoring information was used to develop WLAs and LAs, how much actual information is used in the modeling and how much is based on assumptions and "average" conditions.

DEQ Response: Please see response to Comment 6. For the Benthic TMDL, allocations were based on the total average annual sediment loading in the reference watershed (area adjusted for comparability to impaired watershed). The difference in sediment loading between the two represents the TMDL (see Chapter 7 of *Benthic TMDL Development for Roanoke River*).

In the Bacteria TMDLs, the calibrated HSPF model was used as a platform to simulate adjustments of bacteria source load reductions across the landuses in each watershed with impaired stream segment(s) until bacteria water quality standards were met based on modeled bacteria in-stream concentrations.

EPA details their rationale for approving the aforementioned TMDLs in a document that is accessible on DEQ's website (http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/TMDL/TMDLDevelopment/ApprovedTMDLReports.aspx). Direct links are as follows:
http://www.deq.virginia.gov/portals/0/DEQ/Water/TMDL/apptmdls/epa/epatink.pdf
http://www.deq.virginia.gov/portals/0/DEQ/Water/TMDL/apptmdls/epa/epawilor.pdf
http://www.deq.virginia.gov/portals/0/DEQ/Water/TMDL/apptmdls/epa/eparoabc.pdf

Roanoke County Comment 8: Exactly what model was used for modeling and could that model be made available to the localities to use as a part of their tracking mechanism to show progress? If not, what mechanism does DEQ want the MS4 localities to follow to quantify progress?

DEQ Response: HSPF was used to develop bacteria TMDLs. The Generalized Watershed Loading Function (GWLF) was used to determine sediment loading. Extensive stakeholder participation and water quality monitoring data (including bacterial source tracking) were included as part of the development effort. HSPF is available through the USGS: http://water.usgs.gov/software/HSPF/. GWLF is also available for download on the internet. Various versions exist. WLAs should be addressed in TMDL Action Plans and localities are encouraged to discuss MS4 requirements with DEQ MS4 Staff. Modeling is one of many tools that can be employed to demonstrate compliance but may not be required.

Roanoke County Comment 9: As I have mentioned previously, using the simple method for this calculation indicates that Roanoke County has already reached most of its WLAs goals.

DEQ Response: WLAs should be addressed in TMDL Action Plans and localities are encouraged to discuss MS4 requirements with DEQ MS4 Staff. Modeling is one of many tools that can be employed to demonstrate compliance but may not be required. Until such time that existing TMDLs are superseded by the State Water Control Board and EPA approved TMDL, WLAs established in the *Bacteria TMDLs for Wilson Creek, Ore Branch and Roanoke River Watersheds, Virginia; Roanoke River PCB TMDL Development (Virginia); Fecal Coliform Total Maximum Daily Load Development for Glade Creek, Tinker Creek, Carvin Creek, Laymantown Creek and Lick Run* and *Benthic TMDL Development for the Roanoke River, Virginia* are considered the target WLA for a given permittee. See also Response to Roanoke County Comment 2.

Approaches for Estimating PCB Loadings from MS4s and Non-regulated Storm Water for TMDL Development of the Tidal James River Estuary

(3/1/2012)

Regulated Municipal Separate Storm Sewer System (MS4) storm water and non-regulated storm water have the potential to discharge a significant load of Polychlorinated Biphenyls (PCBs) to the tidal James River estuary. Similar to the other source categories undergoing investigation for PCB loadings (point sources, CSOs, contaminated sites, and atmospheric deposition), some level of effort and resources should be expended to ensure establishment of the most realistic loadings from storm water. Given that Waste Load Allocations (WLAs) for MS4 permits must be included in the tidal James River PCB TMDL, the need for determining whether the assigned baseline allocations exceed the WLAs will be necessary from representative MS4 outfalls. Lacking actual PCB data during TMDL development will lead to the derivation of baseline storm water loads using best available estimations. This can result in overly conservative modeled allocations thus increasing the possibility for reductions from MS4s through a Pollutant Minimization Plan (PMP).

The purpose of this document is to identify a list of approaches for estimating storm water derived PCB loadings from the James River estuary. Therefore, the selection of a method will depend on the availability of resources to generate PCB storm water data. Included in the discussion is a single PCB loading calculation approach that requires data be generated. Conversely, if storm water PCB data are not available, two options for estimating PCB loadings are also presented. With input from the regulated community, an approach will be selected to calculate PCB storm water loads as part of the PCB Total Maximum Daily Load (TMDL) development for the James and Elizabeth Rivers.

I. Calculation of PCB storm water loadings when MS4 data are available

Two methods that require storm water PCB data were initially considered for development of PCB storm water loads to the James River estuary. DEQ and VIMS favored a statistical approach that uses a regression model and was successfully employed in the development of storm water loads in the Baltimore Harbor PCB TMDL (MDE 2011). Although this approach was preferred, the time and resources necessary for proper implementation were significant (monthly samples at several sites for a period of a year). Given the existing circumstances, the recommended approach to be used if appropriate storm water data are available is the Event Mean Concentration.

1) Event Mean Concentration

A simplified method for estimating the long-term mean storm water based pollutant loading is the Event Mean Concentration (EMC). The method has also been referred as Nonpoint Pollution Loading Factors (WMM 1998) and is applicable to both regulated and non-regulated storm water. The EMC is defined as the mean concentration of PCBs found in storm water over the quickflow component of an event hydrograph. Depending on the availability of data used to calculate the EMC, this approach is also applicable for short-term loading estimation. The strength of the approach is it is suitable for load allocations and estimating storm water reductions.

The pollution loading factor M_L is computed for each land use L by the following Equation:

$$M_L = EMC_L * R_L * K \qquad (1)$$

Where:
M_L = loading factor for land use L (lbs/ac/year)
EMC_L = event mean concentration of runoff from land use L (mg/l); EMC_L varies by land uses
R_L = total average annual surface runoff from land use L (in/year)
K = a unit conversion constant (0.2266).

Annual runoff can be estimated based on precipitation and the runoff coefficient:

$$R_L = [C_P + (C_I - C_P)\, IMP_L]*I \quad (2)$$

Where:
R_L = total average annual surface runoff from land use L (in/yr);
IMP_L = fractional imperviousness of land use L;
I = long-term average annual precipitation (in/yr)
C_P = pervious area runoff coefficient; and
C_I = impervious area runoff coefficient

The EMC can be computed using the following equation:

$$EMC = \frac{M}{V} = \frac{\int C(t)Q(t)dt}{\int Q(t)dt} \quad (3)$$

Where C(t) is a smooth real-valued function of time that represents the pollutant concentration curve and Q(t) is also a smooth real-valued function of time that represents the storm water flow rate curve.

However, in practice, the integrals are the functions of Q(t) and C(t), and include approximations created by discrete measurements of Q(t) and C(t). If we assume that we measure the concentrations and the flow rates at equal time intervals in a storm event, the EMC can be estimated as:

$$EMC = \frac{\Sigma C_i Q_i}{\Sigma Q_i} \quad (4)$$

where Q_i and C_i are the respective measurements for the discharge rate and pollutant concentration in the i^{th} interval.

Ideally, this approach requires measurements of flow (Q_i) and PCB concentration (C_i) for the entire storm period which results in the collection and analysis of several PCB samples. With limited resources this option is not practical. Using the assumption that PCB contamination of the watershed is consistent within land uses, and is primarily due to the erosion of historical pollutant sources as well as atmospheric deposition, the PCB concentrations should not vary substantially between storms within each land use. Therefore, in theory, it is feasible to measure PCBs for a storm event to estimate the mean EMC. While preferred, and as resources allow, it may be necessary to evaluate two or more events at a site (within a land use) to obtain confirmation.

Studies have shown that contaminants in the first flush during a storm event (i.e., the discharge of a larger mass or higher concentration in the early part of a storm relative to the later part of the storm, http://www.stormh2o.com/march-april-2008/pollutants-run-off.aspx) tend to be higher although that may be dependent on the size of the watershed and the time of travel for runoff to arrive at the sampling point. Therefore, it would be ideal to collect samples from the first flush (grab sample) followed by two grab samples after the first flush. Based on the logistical difficulty of timing storm events and collecting the associated runoff, it is not always realistic that the first flush can be obtained at targeted sites (composite samplers can be used but at an elevated cost). Although PCB concentrations associated with the first flush can be high, the loading is reduced if the flow is low. It may be more logical to obtain as many samples as possible during an event at each site regardless of the timing. To reduce the cost, a feasible approach is to use a manual composite sample which consists of aliquots of two or more grab samples (either distributed equally or as flow weighted aliquots) that are combined under clean laboratory conditions. In this way, it will be possible to obtain multiple samples at each site during a storm event, then composite the samples which reduce costs while allowing an estimate of the EMC. To account for this, the EMC equation (4) can be re-written as follows:

$$EMC = \sum w_i C_i \tag{5}$$

Where $w_i = Q_i/Q$ and Q is the total flow. Flow weights w_i can be estimated by recording the sampling time and precipitation (Eq. 2). By compositing flow weighted aliquots in the laboratory, analytical costs can be reduced.

As loading can vary substantially within each land use, targeting different land uses for sample collection is preferred. Since flow can be difficult to measure, either precipitation or a watershed model approach can provide reasonably accurate flow estimates. DEQ will be providing resources to collect and analyze PCB storm water samples using the low level detection method. DEQ will minimally target 1) a land use such as a forested area to represent background, and 2) include urban sites (one in the Elizabeth River watershed and one located Richmond and/or Hopewell). DEQ strongly encourages the participation of MS4 permittees to provide some level of resources (field personnel, analytical costs or both) to augment the dataset.

A. PCB Data Collection:

The following sampling design considerations are provided in the event resources are available to generate valid storm water data. These ideas, while still limited, expand on those provided above.

Selection of sampling locations

1) Different land uses (residential, commercial, industrial, and background i.e., forested) must be captured with consideration of spatial coverage. Pervious/impervious coverage should also be considered.
2) Sampling stations must be accessible.
    a. Sampling points should be free-flowing in the upper tidal watershed and free of tidal influence/collected when the tide is low in the lower James River watershed.

Possible sample collection approaches are considered:

1) First flush (only) grab samples
   a. Advantages – a single sample would be collected at each site therefore requiring less field staff time.
   b. Disadvantages – there is potential for underestimating PCB loads with a single sample.
2) A first flush grab sample followed by one (or more) grab sample(s). Analyze individual samples and calculate a mean PCB concentration. The alternative is to composite the samples (in the laboratory) to decrease analytical costs & increase the number of stations/events. This can be accomplished by compositing flow weighted aliquots or equitably distributed volumes.
   a. Advantage – may be more reflective of average concentration of an event.
   b. Disadvantage – significant logistical resources to target first flush and time needed on site to wait for subsequent grabs.
3) Flow proportioned automated composite samples. Collection of aliquots of SW samples over the duration of the storm.
   a. Advantages – composited aliquots reflective of event PCB concentration.
   b. Disadvantages – cost associated with "PCB-free equipment", potential vandalism, double analytical cost with equipment blanks, and a reduction in the number of sites. Use of compositing equipment is likely not practical for this pilot study.

Note: For purposes of PCB storm water monitoring under this document, a working definition of first flush will be established at a later time.

II. Approaches for calculating PCB loadings from storm water when MS4 data are not available

The following approaches are only applicable for those instances where actual regulated/non-regulated storm water data are not available but existing ambient based water and/or sediment PCB data are available. There may be instances where literature based values would be applicable in the absence of ambient data. The two approaches are provided in order of preference.

1) Inverse Estimation (Tidal Prism Model)

The basis of the inverse approach is to use existing in-stream PCB observations to back-calculate the load originating from the watershed. The tidal prism model, while typically used in a small creek, is applicable to larger water bodies and can be used to simulate PCB concentrations (MDE 2009). It is assumed that a single volume can represent a water body, and that the pollutant is well mixed in the water body, as shown in Figure 2. Assuming there is no decay, the PCBs enter the water column via loading from upstream sources and the atmosphere (L_f), loading from the open boundary (Q_0C_0), resuspension from the sediment ($V_r AC_2$), and diffusion between sediment-water column interface ($V_dA(F_{do2}C_2 – F_{do1}C)$). PCBs leave the water column via volatilization ($V_vAF_{do1}C_1$), flow to the outside of the embayment (Q_bC_1), and sedimentation ($V_sAF_{p1}C_1$). In the sediment, the PCBs enter the system via settling ($V_sAF_{p1}C_1$), and leave the system via diffusion ($V_dA(F_{do2}C_2 – F_{do1}C)$), resuspension ($V_r AC_2$) and burial to a deeper layer (V_bAC_2). Specifically, the mass balance for the PCBs in the water column and sediment can be written as:

$$\frac{dV_1C_1}{dt} = L_f - V_v A F_{do1} C_1 + (1-\alpha) Q_0 C_0 - Q_b C_1 + V_r A C_2 - V_s A F_{p1} C_1 + V_d A (F_{do2} C_2 - F_{do1} C_1) \quad (6)$$

$$\frac{dV_2C_2}{dt} = -V_r A C_2 + V_s A F_{p1} C_1 - V_d A (F_{do2} C_2 - F_{do1} C_1) - V_b A C_2 \quad (7)$$

Where:

L_f = PCB loading from upstream (point and nonpoint sources) and direct atmosphere deposition;

V_v = volatilization coefficient (m/d);

α = return ratio, which is the percentage of water that flowed to the Chesapeake Bay during the previous ebb tide and flows back to the embayment during the flood tide;

A = area of the embayment (m^2);

Q_0 = quantity of water that enters the embayment through the open boundary (m^3/d);

Q_b = quantity of water that leaves the embayment through the open boundary (m^3/d);

C_0 = tPCB concentrations in the water column of the Chesapeake Bay (ng/L);

C_1 = tPCB concentrations in the water column of the embayment (ng/L);

C_2 = tPCB concentrations in the sediment of the embayment (ng/L);

V_1 = volume of the water column in the embayment (m^3);

V_2 = volume of the active sediment layer of the embayment (m^3);

V_d = diffusive mixing velocity;

F_{p1} = fraction of particular-associated PCBs in the water column;

F_{do1}= fraction of truly dissolved and dissolved organic carbon (DOC)-associated PCBs in the water column;

F_{do2}= fraction of truly dissolved and DOC-associated PCBs in the sediment;

V_r = rates of resuspension (m/d);

V_s = rates of settling (m/d);

V_b = rates of burial (m/d).

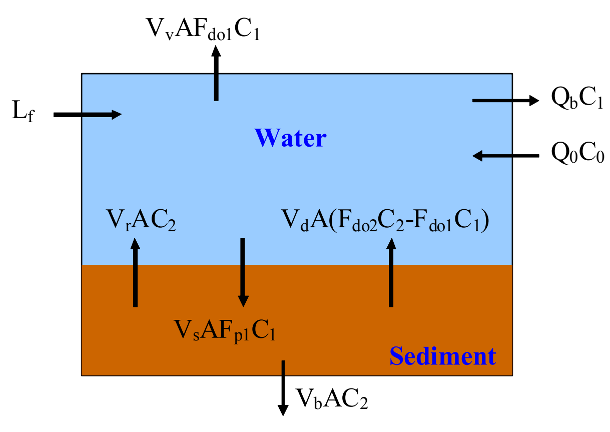

Figure 2: The Schematic Diagram for the Tidal Prism Model and the PCB Budget

If the PCB concentrations in the sediment, the water column, and at the boundary are known, the PCB loading can be estimated by mass balance equations (6) and (7), assuming that it is steady-state. The total loading consists of both urban and nonurban land uses. Therefore, a partition method based on previous and impervious areas can be used to estimate storm water loadings.

A main advantage of this approach over the alternative is that it uses existing water column and river sediment PCB data originating from the watershed. It also provides total nonpoint source PCB loadings from the watershed. Along with the James River mainstem, it is possible to extend this approach into tributaries such as the Elizabeth River, the Chickahominy River as well as other large tributaries. Sufficient spatial resolution of PCB data (i.e., boundary conditions including upstream and near the mouth of the tributaries) is necessary, and would be incorporated into a 3D inverse model.

A shortcoming of the approach is there is a large dependence on the bottom sediment deposition as well as parameters used for the inverse estimation of loadings. Furthermore, the loading estimations will be based on minimal temporal variance of the data. The feasibility to extrapolate isolated results an entire year depends greatly on the available observations.

2) Reference Watershed Approach

If storm water PCB data are not available, application of the Reference Watershed approach can provide an initial estimation of loads. However, this approach cannot be expected to provide a reliable assessment of storm water loading as the conditions and PCB background concentrations can vary substantially between different sub-watersheds within the tidal James system.

Three PCB TMDLs have been developed in the upper Chesapeake Bay watershed. Included are the multi-jurisdictional Potomac River (ICPRB 2007), and the Maryland based TMDLs for Baltimore Harbor (MDE 2011) and Northeast River (MDE 2009). The Baltimore Harbor region can be considered similar to the urban areas of the tidal James River including the Tidewater cities as well as Richmond and Hopewell. Other areas, such as the Northeast River and some of the tributaries that flow into the Potomac, are rural areas with minimal industrial impact. As such, it is possible to use PCB data or loading estimates from these reference watersheds.

The inherent weakness of this method is that it will not provide an accurate estimation of PCB loadings specific to the James River estuary. If it is determined this approach must be used due to limited resources needed to collect PCB storm water data, or the Inverse Estimation method is not appropriate, it is recommended the approach only be used in combination with existing ambient PCB observations.

Reference

WMM 1998. Rouge River National Wet Weather Demonstration Project. User's Manual: Watershed Management Model Version 4.1, Technical memorandum. Retrievable from: http://www.rougeriver.com/proddata/wmmmanul.pdf

ICPRB (Interstate Commission on the Potomac River). 2007. *Total Maximum Daily Loads of Polychlorinated Biphenyls (PCBs) for Tidal Portions of the Potomac and Anacostia Rivers in the District of Columbia, Maryland, and Virginia (Draft)*. Prepared for District of Columbia Department of the Environment, Maryland Department of the Environment, and Virginia Department of Environmental Quality. September 28, 2007. Retrievable from: http://www.potomacriver.org/cms/index.php?option=com_content&view=article&id=136-tidal-pcb-tmdl&catid=41-pollution

MDE 2011. Total Maximum Daily Loads of Polychlorinated Biphenyls in Baltimore Harbor, Curtis Creek/Bay, and Bear Creek Portions of Patapsco River Mesohaline Tidal Chesapeake Bay Segment, Maryland. Retrievable from: http://www.mde.state.md.us/programs/Water/TMDL/DraftTMDLforPublicComment/Pages/TMDL_PN_Baltimore_Harbor_PCBs.aspx

MDE 2009. Total Maximum Daily Loads of Polychlorinated Biphenyls in Northeast River, Tidal Fresh Segment, Cecil County, Maryland. Retrievable from: http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_final_Northeast_River_PCBs.aspx